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# NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

## TECHNICAL NOTE

No. 1837

ELEVATED-TEMPERATURE COMPRESSIVE STRESS-STRAIN DATA FOR

24S-T3 ALUMINUM-ALLOY SHEET AND COMPARISONS

WITH EXTRUDED 75S-T6 ALUMINUM ALLOY

By William M. Roberts and George J. Heimerl

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Langley Air Force Base, Va.

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24S-T3 ALUMINUM-ALLOY SHEET AND COMPARISONS

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SUMMARY

Results are presented of compressive stress-strain tests of 24S-T3 aluminum-alloy sheet at stabilized elevated temperatures up to 700° F, exposure times of 1/2 to 2 hours, and strain rates of 0.002 to 0.006 per minute. Some general comparisons with extruded 75S-T6 aluminum alloy are included.

INTRODUCTION

In a recent investigation, compressive stress-strain data for extruded 75S-T6 aluminum alloy were obtained at elevated temperatures for correlation with compression plate-buckling tests made at the same temperatures. (See reference 1.) The results showed that methods satisfactory for calculating the critical compressive stress at room temperatures could also be used at elevated temperatures provided that the compressive stress-strain curve at the temperature, strain rate, and exposure time was given.

In order to provide additional basic information on compressive stress-strain relations at elevated temperatures for aluminum alloys used in aircraft construction, compressive stress-strain tests were made of 24S-T3 aluminum-alloy sheet at stabilized temperatures up to 700° F, strain rates from 0.002 to 0.006 per minute, and exposure periods of 1/2 to 2 hours. The test procedure and equipment used were the same as that described in reference 1. The single-thickness specimens, 2.52 inches long by 1.00 inch wide, were all cut from the same 0.125-inch-thick sheet. The results of the tests together with a few general comparisons with extruded 75S-T6 aluminum alloy are presented herein.

## RESULTS AND DISCUSSION

The results of the compressive stress-strain tests for 24S-T3 aluminum-alloy sheet are shown in figures 1 to 7 with comparative data on extruded 75S-T6 aluminum alloy given in figures 1, 3, and 5.

Compressive stress-strain curves for 24S-T3 aluminum-alloy sheet for temperatures up to 700° F are summarized in figure 1 for a strain rate of 0.002 per minute and exposure time of 1 hour together with data for extruded 75S-T6 aluminum alloy taken from reference 1. For this strain rate and exposure time, the compressive yield stress  $\sigma_{cy}$  for 24S-T3 aluminum-alloy sheet first decreases and then increases with elevated temperatures, so that  $\sigma_{cy}$  is greater at 400° F than at room temperature. Above 400° F, however, a rapid decrease in  $\sigma_{cy}$  occurs. The general comparison between 24S-T3 aluminum-alloy sheet and extruded 75S-T6 aluminum alloy (see fig. 1) indicates that for temperatures above 400° F, 24S-T3 aluminum-alloy sheet is markedly superior to extruded 75S-T6 aluminum alloy with regard to both Young's modulus  $E$  and  $\sigma_{cy}$ ; but for temperatures less than about 400° F, there is little difference in  $E$  although extruded 75S-T6 aluminum alloy is appreciably stronger.

The effects of variation in exposure time and strain rate on the stress-strain curve for 24S-T3 aluminum-alloy sheet are shown in figure 2 for various temperatures. The material appears to be sensitive to both these factors for temperatures of about 400° F and above.

The variation of  $\sigma_{cy}$  with temperature for exposure times of 1/2, 1, or 2 hours is shown in figure 3 together with a comparative curve for extruded 75S-T6 aluminum alloy (from NACA, reference 1) and data on the tensile yield stress  $\sigma_{ty}$  for 24S-T aluminum-alloy products except extrusions (from ANC-5, reference 2). The effects of precipitation hardening on the strength of 24S-T3 aluminum-alloy sheet are readily apparent for the three different exposure times and account in part for the appreciable difference found with the results for extruded 75S-T6 aluminum alloy. The agreement between the tensile data and the compressive results for 24S-T3 aluminum-alloy sheet is rather poor.

The effect of the variation of exposure time on the compressive yield stress is also given in figure 4 for tests at various temperatures. A decrease in  $\sigma_{cy}$  with exposure time is indicated for all the temperatures covered except for 400° F where an increase in  $\sigma_{cy}$  occurs for exposure times of 1 and 2 hours.

The decrease in Young's modulus  $E$  with temperature is shown in figure 5 together with a comparative curve for extruded 75S-T6 aluminum alloy taken from reference 1. The reduction is considerably less for

24S-T3 aluminum-alloy sheet than for extruded 75S-T6 aluminum alloy over the entire temperature range but particularly for temperatures above 400° F. Variations in exposure time apparently had little effect on E regardless of the temperature. (See fig. 6.)

For convenience in estimating plate and column strengths, the variation of the secant and tangent moduli with temperature is shown in figure 7 for a strain rate of 0.002 per minute and for an exposure time of 1 hour. These curves were derived from the stress-strain curves of figure 1.

### CONCLUSIONS

In summarizing the results of the compressive stress-strain tests of 24S-T3 aluminum-alloy sheet at stabilized elevated temperatures up to 700° F, exposure times from 1/2 to 2 hours, and strain rates of 0.002 to 0.006 per minute, the following conclusions may be drawn:

1. The compressive yield stress first decreases slightly and then may increase with temperature depending on the exposure time, but above 400° F a rapid decrease occurs. The compressive yield stress is moderately insensitive to changes in exposure times and strain rates until a temperature of about 400° F is reached, after which the compressive yield stress becomes more sensitive to these factors.

2. Young's modulus shows a steady decrease with temperature but is relatively insensitive to the variations of strain rates or exposure times covered by these tests.

3. The compressive yield stress for extruded 75S-T6 aluminum alloy is markedly greater than that for 24S-T3 aluminum-alloy sheet at room temperatures; whereas at 400° F and above, the compressive yield stress for 24S-T3 aluminum-alloy sheet is appreciably greater than that for extruded 75S-T6 aluminum alloy. The decrease in Young's modulus with temperature for 24S-T3 aluminum-alloy sheet is considerably less than that for extruded 75S-T6 aluminum alloy over the entire temperature range.

Langley Aeronautical Laboratory

National Advisory Committee for Aeronautics

Langley Air Force Base, Va., January 27, 1949.

#### REFERENCES

1. Heimerl, George J., and Roberts, William M.: Determination of Plate Compressive Strengths at Elevated Temperatures. NACA TN No. 1806, 1949.
2. Anon.: Strength of Metal Aircraft Elements. ANC-5, Army-Navy-Civil Committee on Aircraft Design Criteria. Revised ed., Dec. 1942; Amendment 2, Aug. 8, 1946.

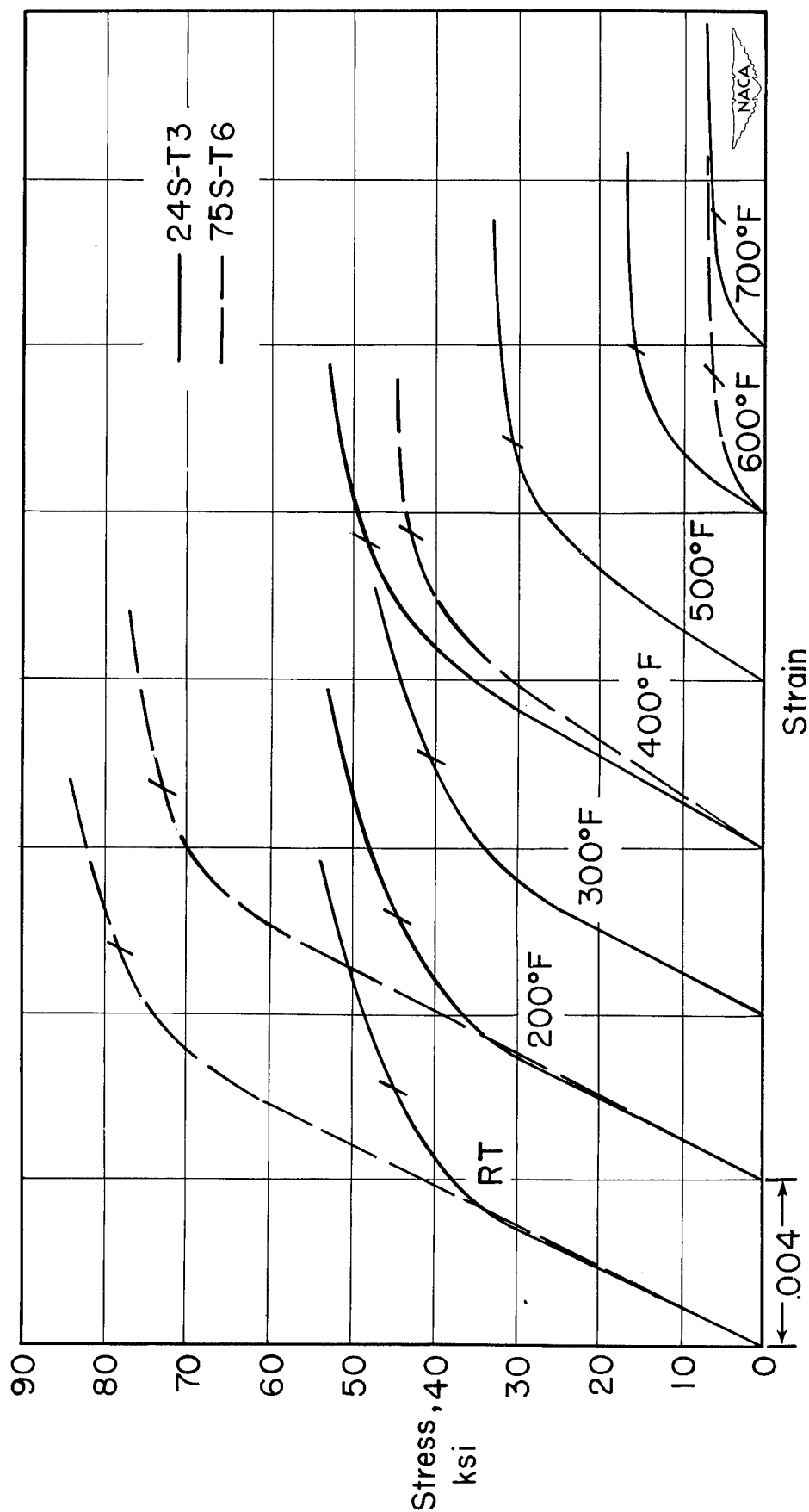


Figure 1.- A general comparison of the compressive properties of 24S-T3 aluminum-alloy sheet and 75S-T6 extruded aluminum alloy at elevated temperatures for a strain rate of 0.002 per minute and an exposure time of 1 hour. (RT, Room temperature)

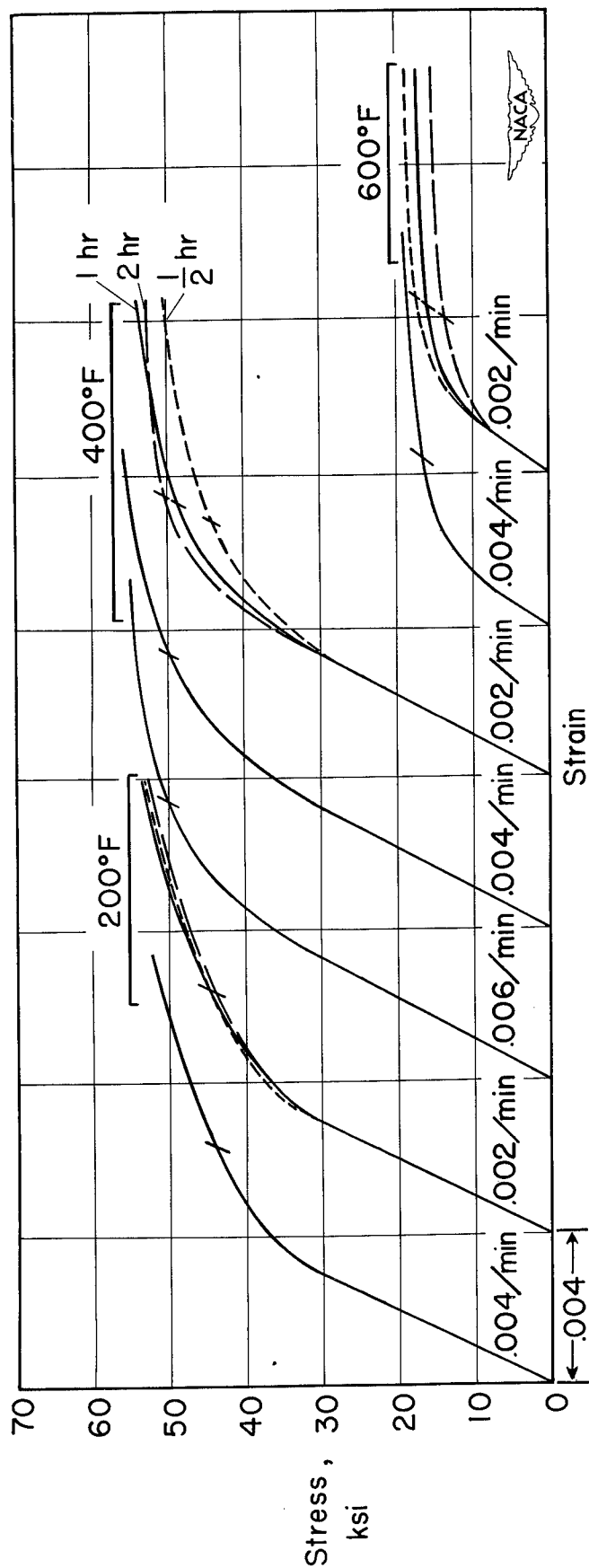


Figure 2.- Compressive stress-strain curves for 24S-T3 aluminum-alloy sheet for various strain rates, temperatures, and exposure times.

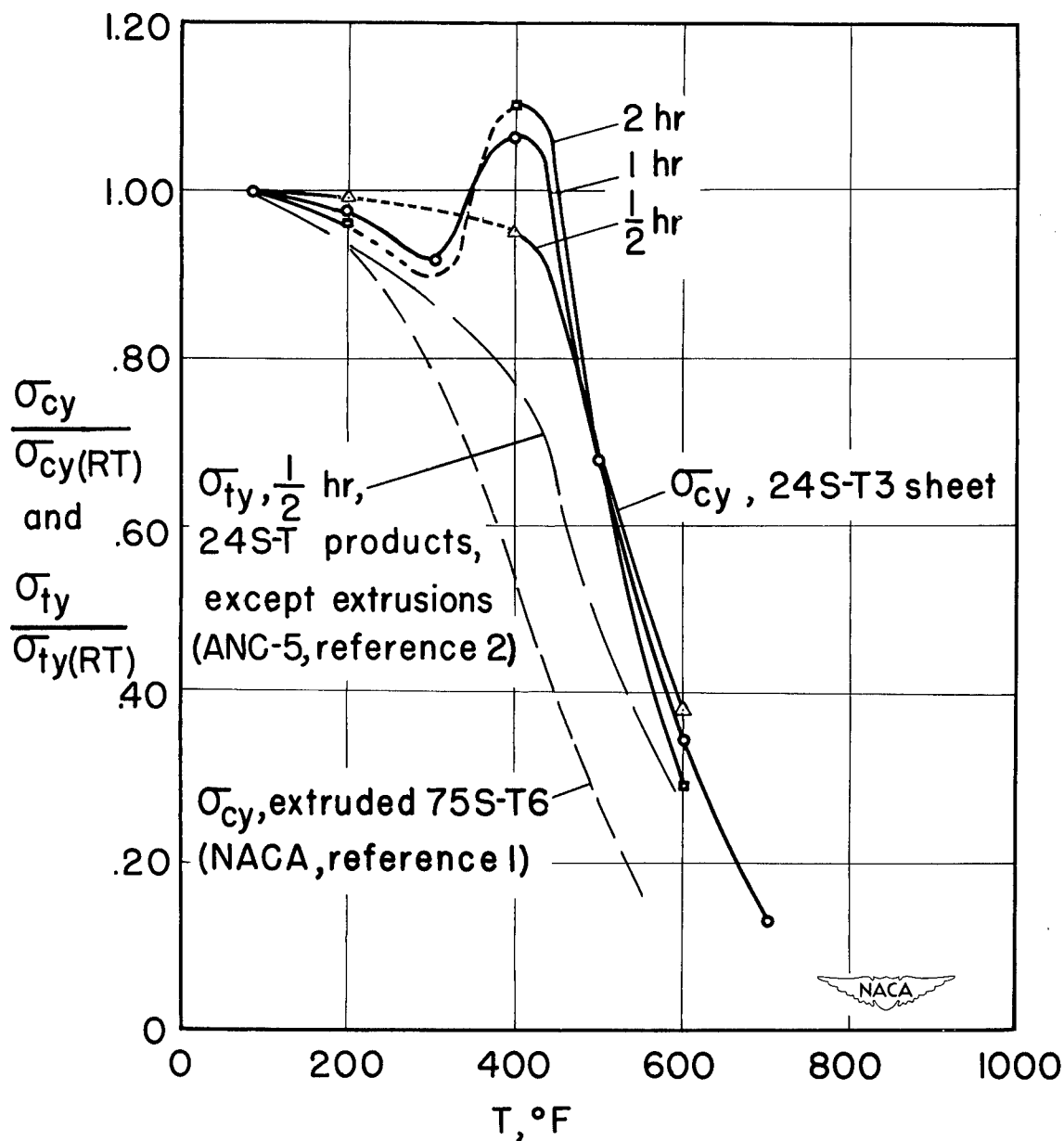


Figure 3.- Variation of the compressive yield stress  $\sigma_{cy}$  and tensile yield stress  $\sigma_{ty}$  with temperature  $T$  for 24S-T3 aluminum-alloy sheet for a strain rate of 0.002 per minute. (RT, Room temperature)



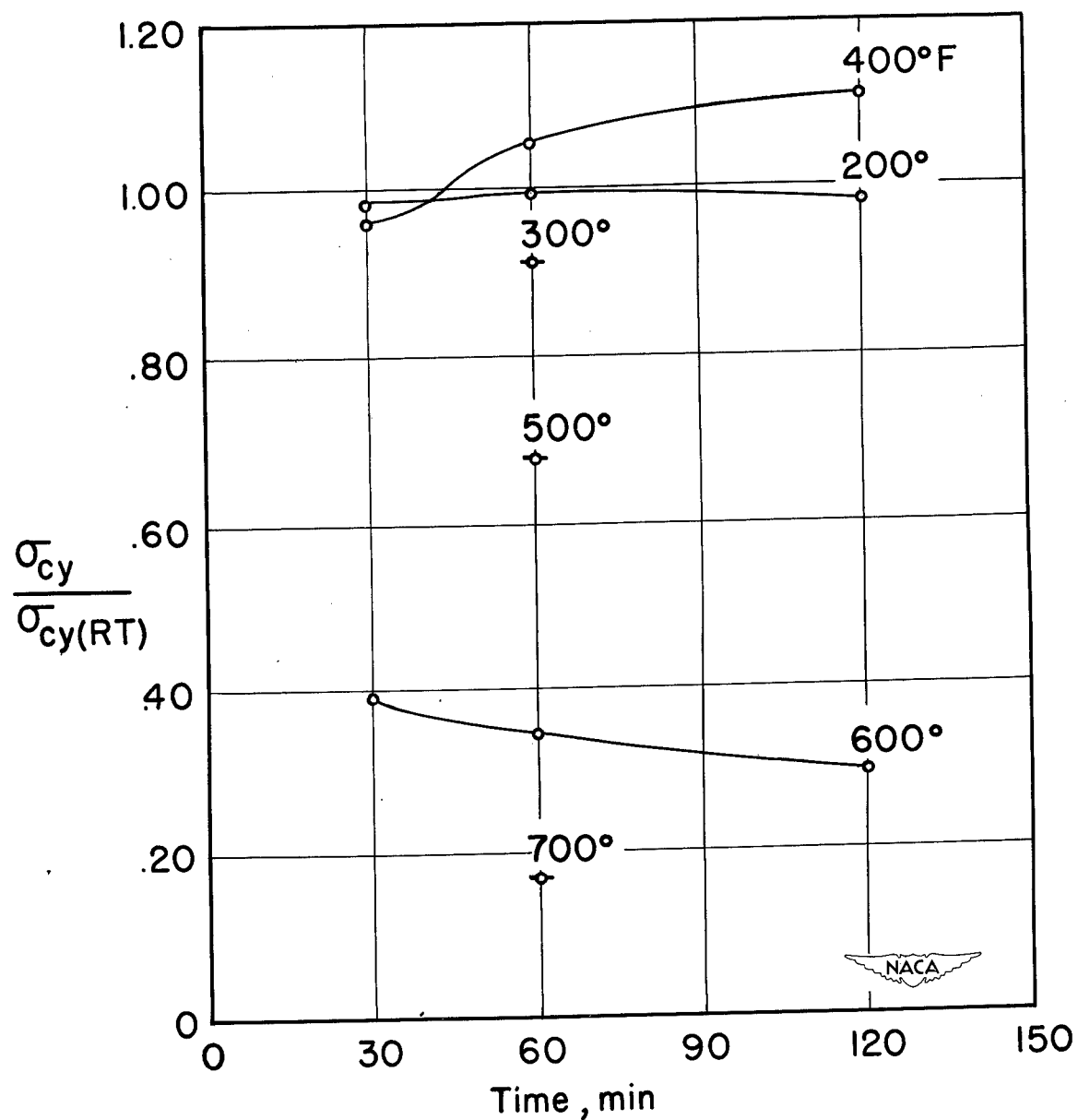


Figure 4.- Variation of the compressive yield stress  $\sigma_{cy}$  with time for 24S-T3 aluminum-alloy sheet for a strain rate of 0.002 per minute. (RT, Room temperature)

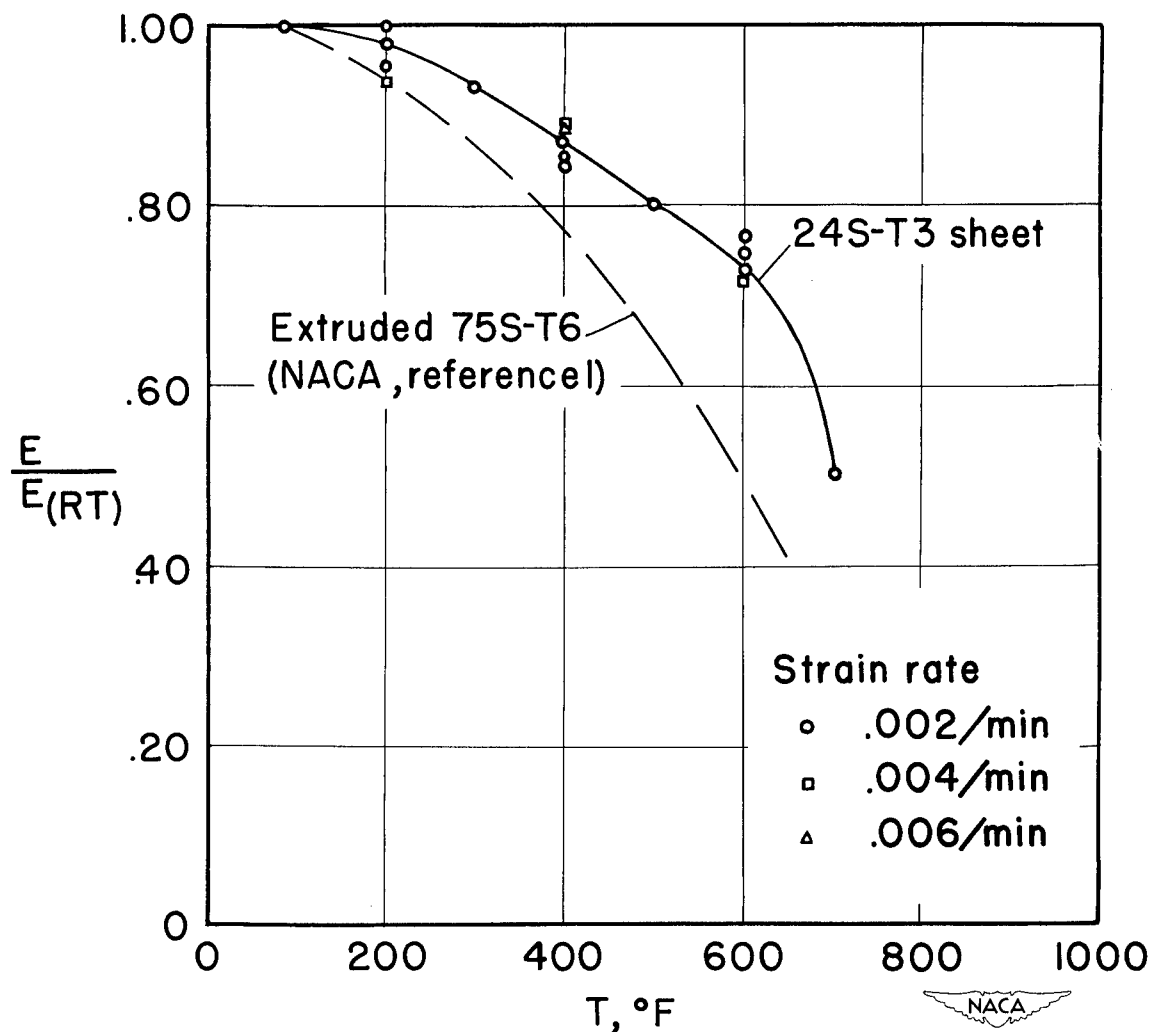


Figure 5.-Variation of Young's modulus  $E$  with temperature  $T$  for 24S-T3 aluminum-alloy sheet for a strain rate of 0.002 per minute. (RT, Room temperature)

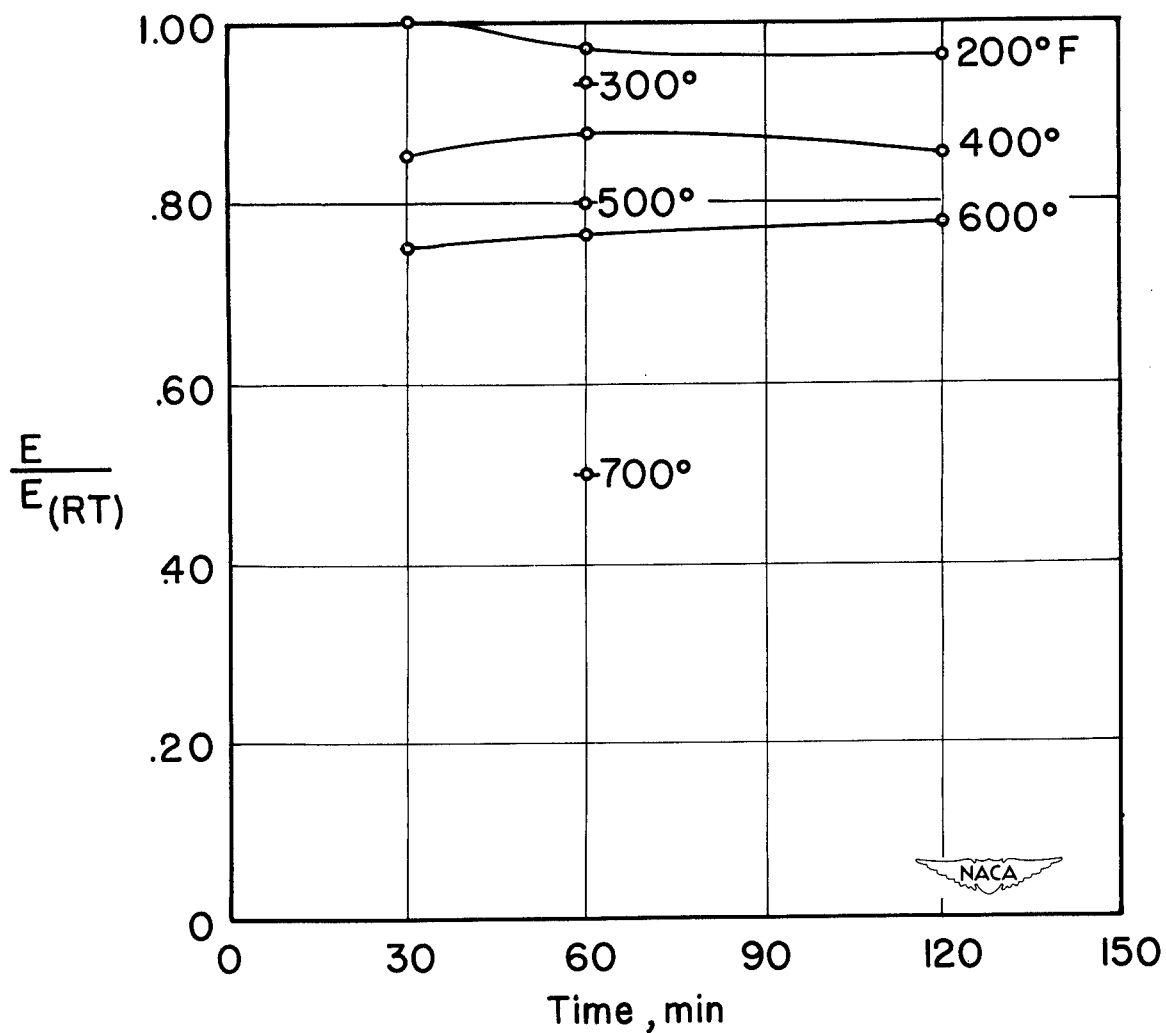


Figure 6.- Variation of Young's modulus  $E$  with time for 24S-T3 aluminum-alloy sheet for a strain rate of 0.002 per minute (RT, Room temperature)

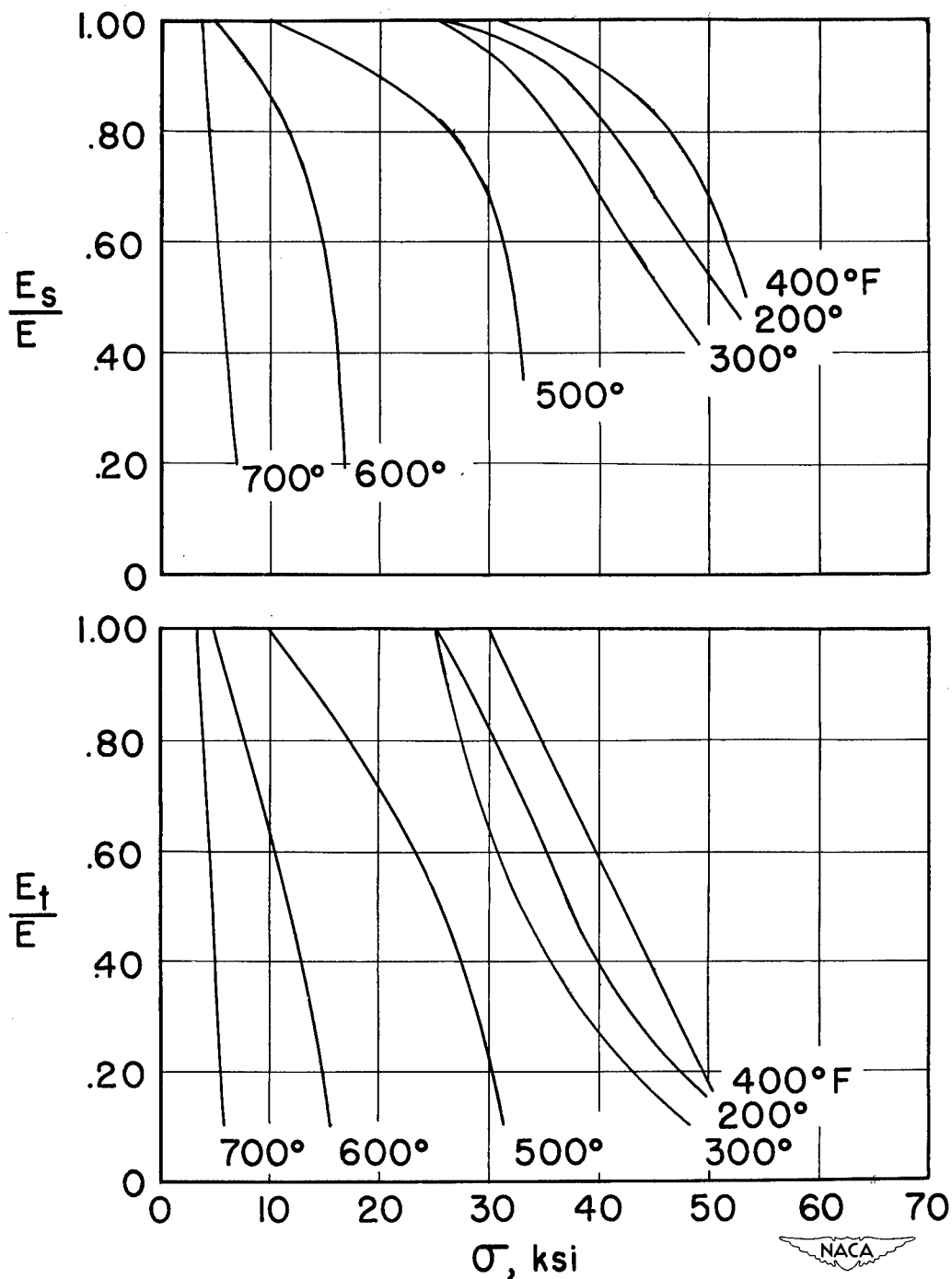


Figure 7.-Variation of the secant modulus  $E_s$  and the tangent modulus  $E_t$  with stress for a strain rate of 0.002 per minute and an exposure time of 1 hour for 24S-T3 aluminum-alloy sheet.